10/089051

Rec'd PCT/PTO 25 MAR 2002

P22145

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : Dan-Keun SUNG et al.

Appl No. : Not Yet Assigned PCT Branch

I.A. Filed : 06 February 2001 PCT/KR01/00166

For : MULTI-DIMENSIONAL ORTHPGONAL RESOURCES HOPPING MULTIPLEXING COMMUNICATIONS METHOD AND APPARATUS

CLAIM OF PRIORITY

Commissioner of Patents and Trademarks

Washington, D.C. 20231

Sir:

Applicant hereby claims the right of priority granted pursuant to 35 U.S.C. 119 based upon Korean Application No 2000-29400 filed 30 May 2000. The International Bureau already should have sent a certified copy of the Korean application to the United States designated office. If the certified copy has not arrived, please contact the undersigned.

Respectfully submitted,
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10/089051
Rec'd PCT/PTO 25 MAR 2002

SUBMISSION OF CORRECTION

To : Commissioner of
the Korean Industrial Property Office

International Application No.	PCT/KR01/00166	International Filing Date	06. 02. 2001	Priority Date	30. 05. 2000

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☐ Submitted hereby is a correction pursuant to Article 106-33(2) of the Enforcement Regulations of the Patent Law.

☐ Submitted hereby is a correction pursuant to Article 106-36(3) of the Enforcement Regulations of the Patent Law.

Date(day/month/year) MARCH 13, 2002

Agent LEE, Jong Il (Seal)

※ Attached Document(s) :

1. Two copies of written amendments
2. A copy of the document(s) substantiating the power of attorney, if any

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44/prts

PCT/KR01/00166 Amendment description

(1) 1Page 16Line-17Line

, the present invention is related to a statistical multiplexing method and apparatus

→ the system comprises a primary communication station that synchronizes a plurality of channels to secondary communication stations

(2) 1Page 20Line-23Line

in which the system comprises a primary communication station that synchronizes a plurality of channels to secondary communication stations

→ Delete

(3) 2Page 7Line

one channel transmits data symbol different

→ one channel intends to transmit data symbol different

(4) 2Page 21Line

allocation

→ allocation(FA)

(5) 3Page 2Line-3Line

allocation of an time slot amongst a multitude of time slots which has not been allocated

→ allocation of an time slot amongst a plurality of time slots which have not been allocated

(6) 3Page 26Line

multiplesing method which have been laid open are

→ multiplesing methods which have been laid open are

(7) 4Page 2Line

embodiments of the prior arts and present invention, all

→ embodiments of the prior arts and present invention. All

(8) 5Page 27Line

unit, or frame, (e.g. 20ms in IS-95). Tail bit attachment

→ unit, or frame, (e.g. 20ms in IS-95). A tail bit attachment

(9) 6Page 1Line

block 242 are insterted into the traffic channel, all of

→ block 242 is insterted into the traffic channel, all of

(10) 6Page 10Line

interleaver 248 are scrambled in a scrambler 256 with use of

→ interleaver 248 are scrambled in a scrambler 256 using

(11) 6Page 13Line

whih use of a long code mask 250 gencerated by an electronic

→ by suing a long code mask 250 gencerated by an electronic

(11) 7Page 10Line-11Line

transmitting date by employing a different orthogonal code symbol in FIG. 3a.

→ transmitting date by separately employing a different orthogonal code symbol on each of I/Q channel.

(12) 7Page 27Line

transmitting date by employing a different orthogonal code

→ transmitting date by separately employing a different orthogonal code

(13) 8Page 1Line

symbol in FIG. 3e.

→ symbol on each of I/Q channel.

(14) 9Page 9Line-10Line

318, 338 by a short PN sequence 324, 344 for the primary communication station identification. Signals spread and

→ 318, 338 by a short PN sequence 324, 344 for identification of the primary communication station. Signals spread and

(15) 10Page 5Line

using same QOC mask. Therefore, the present invention is

→ using the same QOC mask. Therefore, the present invention is

(16) 10Page 7Line

QOC mask, which may maintain the orthogonality.

→ QOC mask, in which orthogonality is maintained.

(17) 10Page 11Line

channel transmitting data through a different orthogonal code

→ channels transmitting data through a different orthogonal code

(18) 10Page 14Line-15Line

order to explain the multiplexing method which transmits the signals by allocating orthogonal resource at each channel.

→ order to explain a multiplexing method which transmitting the signals by allocating orthogonal resources at each channel.

(19) 10Page 23Line

the average transmission rate can be a variety of forms such

→ the average transmission rate can be determined with a variety of forms such

(20) 11Page 25Line

transmits a common pilot channel to the secondary

→ transmits a common pilot channel signal to the secondary

(21) 12Page 1Line

tracking, phase estimation and power control, can be

→ tracking, phase estimation and power control, the pilot channal signal

(22) 12Page 14Line-15Line

extensively studied for the purpose of a satellite broadcasting. For the case of OFDM, the

→ extensively studied for satellite broadcasting system. In case of OFDM, the

(23) 13Page 6Line

FIG. 4g shows the regular frequency

→ FIG. 4g shows a regular frequency

(24) 13Page 8Line

FIG. 4h shows the irregular frequency

→ FIG. 4h shows an irregular frequency

(25) 13Page 19Line

the frequency diversity by implementing the time division

→ frequency diversity by implementing the time division

(26) 13Page 22Line

strengthening of the frequency diversity instead of security

→ strengthening the frequency diversity instead of security

(27) 19Page 19Line

multiplexing is fixedly allocation orthogonal resources

→ multiplexing is to fixedly allocate orthogonal resources

(28) 19Page 8Line

processes is required, larger buffer size is required in the

→ processes is required, a larger buffer capacity is required in the

(29) 22Page 17Line-18Line

channels are multiplexed statistically by distinguishing the channels

from multi-dimensional

→ channels are statistically multiplexed by distinguishing the channels throuth multi-dimensional

(30) 26Page 10Line

embodiments of the prior arts and present invention.

→ embodiments of the prior arts and the present invention.

(31) 28Page 6Line

present invention (orthogonal code = frequency).

→ present invention (orthogonal resource = frequency).

(32) 29Page 10Line

according to the embodiments of the present invention in FIG 10a.

→ according to the embodiments of the present invention in FIG. 10a.

(33) 29Page 15Line

according to the embodiments of the present invention in FIG 10b.

→ according to the embodiments of the present invention in FIG. 10b.

(34) 29Page 15Line

according to the embodiments of the present invention in FIG 10c.

→ according to the embodiments of the present invention in FIG. 10c.

(35) 29Page 25Line

according to the embodiments of the present invention in FIG 10d.

→ according to the embodiments of the present invention in FIG. 10d.

(36) 30Page 3Line

according to the embodiments of the present invention in FIG 10e.

→ according to the embodiments of the present invention in FIG. 10e.

(37) 30Page 8Line

according to the embodiments of the present invention in FIG 10f.

→ according to the embodiments of the present invention in FIG. 10f.

(38) 31Page 11Line

transmitting data symbols where collisions occurred in FIG. 14f.

→ transmitting data symbols where collisions occur, as shown in FIG. 14f.

(39) 32Page 4Line

data symbols whers collisions occurred in FIG. 14j.

→ data symbols whers collisions occur, as shown in FIG. 14j.

(40) 32Page 15Line

FIG. 14n illustrates illustrating a collision case (the

→ FIG. 14n illustrates a collision case (the

(41) 32Page 23Line

where collisions occurred in FIG. 14n (the squares filled with

→ where collisions occur, as shown in FIG. 14n (the squares filled with

(42) 33Page 15Line

data symbols where collisions occurred in FIG. 14q.

→ data symbols where collisions occur, as shown in FIG. 14q.

(43) 34Page 5Line

data symbols where collisions occurred in FIG. 14t.

→ data symbols where collisions occur, as shown in FIG. 14t.

(44) 34Page 7Line

from the primary communication station by a irregulat and

→ from the primary communication station by an irregulat and

(45) 34Page 21Line

date symbols where collisions occurred in FIG. 14w.

→ date symbols where collisions occur, as shown in FIG. 14w.

(46) 35Page 11Line

380 : Multi-dimensional (orthogonal Rsource) Hopping

→ 380 : Multi-dimensional (Orthogonal Rsource) Hopping

(47) 35Page 21Line

392, 393 : Symbol position Selector (or Buffer)

→ 392, 393 : Symbol Position Selector (or Buffer)

(48) 36Page 7Line

according to the present invention communicates by selecting

→ according to the present invention is to communicate by selecting by

(49) 36Page 23Line

orthogonal code hopping method against all the orthogonal

→ orthogonal code hopping method to orthogonal resource hopping of all the orthogonal

(50) 37Page 1Line

respectively, in the existing commercialized mobile

→ respectively, in the existing commercial mobile

(51) 37Page 27Line

one-way communication, there is no need for transmitting a

→ one-way communication, there is no need for transmitting

(52) 38Page 13Line

here as Common Physical Control Channel(CPCCH).

→ here Common Physical Control Channel(CPCCH).

(53) 38Page 17Line

command by the time division multiplexing for a plurality of

→ command by time division multiplexing for a plurality of

(54) 42Page 14Line

in symbol unit. In is relatively convenient

→ in a symbol unit. In is relatively convenient

(55) 43Page 17Line

allocating to a channel that generates a relatively bursty

→ allocating to a channel that generates relatively bursty

(56) 43Page 23Line

child code symbols which possess the same parents symbols

→ child code symbols which possess the same parent symbols

(57) 44Page 10Line

primary communication station are constrained by the

→ primary communication station is constrained by the

(58) 44Page 12Line-13Line

handoff occurs at the adjacent cell, a new multi-dimensional hopping pattern should be allocated from the adjacent cell.

→ handoff occurs at an adjacent cell, a new multi-dimensional hopping pattern needs to be allocated from the adjacent cell.

(59) 44Page 23Line-25Line

characteristics, if the channels toward the secondary communication station have a low activity with statistically coarse or bursty traffic, the resources could be wasted.

→ characteristics, if channels toward the secondary communication station have a low activity with statistically sparse or bursty traffic, the

resources could be wasted.

(60) 45Page 3Line-10Line

As a result, collisions between the multi-dimensional hopping patterns where two different channels select an identical multi-dimensional resource coordinate at the same time inevitably occur. Hence, in order to resolve these problem in the present invention, the occurrence of a collision between the hopping patterns is determined with a collision detector and controller 384, 386 by receiving all the hopping patters and data symbols to be transmitted for all channels.

→ As a result, collisions inevitably occur between the multi-dimensional hopping patterns where two different channels select an identical multi-dimensional resource coordinate at the same time. Hence, in order to resolve this problem in the present invention, collisions between the hopping patterns are determined with a collision detector and controller 384, 386 by receiving all the hopping patters and data symbols to be transmitted for all channels.

(61) 45Page 25Line

secondary communication station but even if one the symbols

→ secondary communication station. If one of the symbols

(62) 46Page 3Line-6Line

detector and comparator 384, 386, the inputs for multiplier 385 and 387 become " +1" or " 0" . The transmission stops for the interval where the input for the multiplier is " 0" . In order to compensate for the lack of the average receiving energy of

→ detector and comparator 384, 386, the input for multiplier 385 and 387 becomes " +1" or " 0" . The transmission is off for the interval where the input for the multiplier is " 0" . In order to compensate for a

lack of the average receiving energy of

(63) 46Page 13Line-15Page

communication station by the secondary communication station according to the conventional method can also be carried out.

→ communication station to the secondary communication stations can also be carried out according to the conventional method.

(64) 46Page 16Line-17Line

FIG. 10b shows an implementation method for implementing the

→ FIG. 10b shows an implementation method of the implementing the

(65) 47Page 6Line

data to the I and Q channel is different since it modulates

→ data to the I and Q channels are different since it modulates

(66) 47Page 24Line

It is identical to FIG. 10c except that it is a using a

→ It is identical to FIG. 10c except that it uses a

(67) 48Page 2Line

It is identical to FIG. 10d except that it is using a

→ It is identical to FIG. 10d except that it uses a

(68) 50Page 3Line-4Line

invention in FIG. 10e. It is identical to FIG. 13e except that it despreads by using a quasi-orthogonal code 566.

→ invention in FIG. 10e. It is identical to FIG. 13e except that the received signal is despreading despread by using a quasi-orthogonal code 566.

(69) 50Page 25Line

multiplexing is attempted to the channels 920, 930, like 924,

→ multiplexing can be applied to Channels 920, 930, as taken in Channels 924,

(70) 51Page2Line

FIGs. 14c and 14d illustrate how the hopping

→ FIGs. 14c and 14d illustrate how hopping

(71) 51Page 10Line

multiplexing althouth a collision might occur if independent

→ multiplexing althouth a collision may occur if independent

(72) 51Page 14Line

Multiplexing Method in parallel in a statistically coarse frame

→ Multiplexing Method in parallel in a statistically sparse frame

(73) 51Page 17Line

pattern in the square.

→ pattern in square.

(74) 51Page 22Line-25Line

sub-carrier). The squares whose boundary are represented by a paired dot line indicate the location of data symbols where multi-dimensional hopping patterns are collided and the squares whose boundary are represented by

→ sub-carrier). The squares whose boundary is represented by a paired dot line indicate the location of data symbols where multi-dimensional hopping patterns collide and the squares whose boundary is represented by

(75) 52Page 2Line-4Line

where collisions occur in FIG. 14f. The squares filled with black color indicate transmission even though collisions occurred for multi-dimensional hopping patterns. All data

→ where collisions occur, as shown in FIG. 14f. The squares filled with black color indicate transmission even though collisions among multi-dimensional hopping patterns occur. All data

(76) 52Page 10Line-13Line

the primary communication station by the time division multiplexing method based on symbol units in a statistically coares frame according to the embodiment of the present invention. It is a time division multiplexing based on symbol

→ the primary communication station by a time division multiplexing method based on symbol units in a statistically sparse frame according to the embodiment of the present invention. It is a time division multiplexing scheme based on symbol

(77) 53Page 11Line

The squares whose boundary are represented by a paired dot

→ The squares whose boundary is represented by a paired dot

(78) 53Page 14Line

boundary are represented by a single dot line indicate the

→ boundary is represented by a single dot line indicate the

(79) 53Page 20Line

collisions occurred for multi-dimensional hopping patterns, all

→ collisions among multi-dimensional hopping patterns occur, all

(80) 54Page 7Line

application number 10-1999-0032187) by the same inventor.

→ application number 10-1999-0032187) by the same inventors.

(81) 54Page 23Line

orthogonal code). The squares whose boundary are

→ orthogonal code). The squares whose boundary is

(82) 54Page 26Line

the squares whose boundary are represented by a single dot

→ the squares whose boundary is represented by a single dot

(83) 55Page 5Line-6Line

transmission even though collisions occur for multi-dimensional hopping patterns, all data symbols of

→ transmission even though collisions among multi-dimensional hopping patterns occur, all data symbols of

(84) 56Page 3Line

squares whose boundary are represented by a paired dot line

→ squares whose boundary is represented by a paired dot line

(85) 56Page 5Line

hopping patterns collide and the squares whose boundary are

→ hopping patterns collide and the squares whose boundary is

(86) 56Page 10Line

symbols where collisions occur in FIG. 14q. The squares filled

→ symbols where collisions occur, as shown in FIG. 14q. The squares filled

(87) 56Page 12Line

occur for multi-dimensional hopping patterns, all data

→ occur among multi-dimensional hopping patterns, all data

(88) 57Page 4Line

squares whose boundary are represented by a paired dot line

→ squares whose boundary is represented by a paired dot line

(89) 57Page 6Line

hopping patterns collide and the squares whose boundary are

→ hopping patterns collide and the squares whose boundary is

(90) 57Page 11Line

where collisions occur in FIG. 14t. The squares filled with

→ where collisions occur, as shown in FIG. 14t. The squares filled with

(91) 57Page 13Line

for multi-dimensional hopping patterns, all data symbols of

→ among multi-dimensional hopping patterns, all data symbols of

(92) 57Page 21Line

hopping multiplexing in FIG. 14l coexist. It is a composite

→ hopping multiplexing in FIG. 14l coexist. It is a combined

(93) 58Page 15Line

orthogonal code). The squares whose boundary are

→ orthogonal code). The squares whose boundary is

(94) 58Page 18Line

the squares whose boundary are represented by a single dot

→ the squares whose boundary is represented by a single dot

(95) 58Page 23Line

symbols where collisions occur in FIG. 14w. The squares filled

→ symbols where collisions occur, as shown in FIG. 14w. The squares filled

(96) 60Page 17Line

(2) Symbol Puncturing Probability

→ (2)Symbol Punctuation Probability

(97) 60Page 21Line

(3) Symbol Puncturing Probability when all π_i' s are

→ (3) Symbol Punctuation Probability when all π_i' s are

(98) 61Page 12Line

(1) Symbol Puncturing Probability

→ (1) Symbol Punctuation Probability

(99) 61Page 16Line

(3) Symbol Puncturing Probability when all πi' s are

→ (3) Symbol Punctuation Probability when all πi' s are

(100) 62Page 10Line

(2) Symbol Puncturing Probability

→ (2) Symbol Punctuation Probability

(101) 62Page 14Line

(4) Symbol Puncturing Probability when all πi' s are

→ (4) Symbol Punctuation Probability when all πi' s are

(102) 63Page 17Line

(1) Symbol Puncturing Probability

→ (1) Symbol Punctuation Probability

(103) 63Page 21Line

(2) Symbol Puncturing Probability when all πi' s are

→ (2) Symbol Punctuation Probability when all πi' s are

(104) 64Page 11Line

The transmission stoppage due to the collision of multi-

→ Due to the collision of multi-

(105) 64Page 13Line

transmission data symbols occurs in a channel group that

→ transmission data symbols occurs, transmission is ' off' in a channel group that

(106) 64Page 15Line

primary communication station. Whan a smart antenna like in

→ primary communication station. When a smart antenna like in

(107) 64Page 16Line-17Line

FIG. 16 whose transmission antenna beam 1120, 1130, 1140 toward the primary communication station exists in plurality,

→ FIG. 16 whose transmission antenna beams 1120, 1130, 1140 toward the primary communication station exist in plurality,

(108) 64Page 20Line

beam 1130, 1140 in a collision interval is not stopped.

→ beams 1130, 1140 in a collision interval is not stopped.

(109) 65Page 1Line-2Line

receiver' s side are absolutely needed in order to recover the data that exist between a lost interval from the receiver' s side

→ receiver' s side are absolutely needed in order to recover the lost data during a lost interval from the receiver' s side

(110) 65Page 4Line

transmitted during the interval where the multi-dimensional

→ transmitted during the interval where multi-dimensional

(111) 65Page 9Line

proposed by the present invention can equally be implemented

→ proposed by the present invention can equally be applied

(112) 65Page 18Line

resource, a decrease in signaling traffic due to unnecessary

→ resources, a decrease in signaling traffic due to unnecessary

(113) 66Page 1Line

resource patterns are selected pseudo randomly in comparison

→ resource patterns are selected pseudo-randomly in comparison

(114) 67Page 24Line-25Line

a collision detector and controller that detects whether a collision occurs or not between the multi-dimensional hopping patterns and compares the consistency of the data symbols

→ a collision detector and controller that detect whether a collision occurs or not among the multi-dimensional hopping patterns and compare the consistency of the data symbols

(115) 69Page 10Line

orthogonal resource hopping multiplexing method which

→ orthogonal resource hopping multiplexing method in which

(116) 71Page 23Line

multi-dimensional dimensional orthogonal resource hopping

→ multi-dimensional orthogonal resource hopping

(117) 73Page 13Line

hopping multiplexing is carried out for statistically coarse or

→ hopping multiplexing is carried out for statistically sparse or

(118) 78Page 25Line-26Line

orthogonal resource hopping patterns shows that not all the transmitting data symbols of corresponding channels are

→ orthogonal resource hopping patterns shows that all the transmitting data symbols of corresponding channels are not

(119) 79Page 27Line

wherein said two system parameters are equal to or

→ wherein said two system parameter values are equal to or

(120) 86Page 18Line-21Line

and controller that detects whether a collision occurs or not between the multi-dimensional hopping patterns and compares the consistency of the data symbols toward the secondary communication

stations between said collision

→ and controller that detect whether a collision occurs or not among the multi-dimensional hopping patterns and compare the consistency of the data symbols toward the secondary communication stations in said collision

Multi-Dimensional Orthogonal Resource Hopping Multiplexing Communications Method and Apparatus

TECHNICAL FIELD

The present invention is related to a statistical multiplexing method and apparatus for the channels using a multi-dimensional orthogonal resource hopping multiplexing method when the data transmission rate for each channel has an average transmission rate which is lower than the basic transmission rate (R) in digital communication systems where a plurality of communication channels synchronized through a single medium with a low degree of activity co-exist.

More specifically, the system comprises a primary communication station that synchronizes a plurality of channels to secondary communication stations wherein the primary communication station identifies each channel of the secondary communication station by the multi-dimensional orthogonal resource hopping pattern; the multi-dimensional orthogonal resource hopping pattern corresponding to a secondary communication station comprises a designated hopping pattern assigned at the time of a call establishment or a pseudo-random hopping pattern unique to the secondary communication station; when the multi-dimensional orthogonal resource coordinates within the hopping patterns

of more than two channels at any moment are the same (herein referred to as "collision of multi-dimensional orthogonal resource hopping patterns"), all the transmitting channels from the primary communication station involved with the collision are compared and if at least one channel intends to transmit data symbol different from other channels, then the corresponding symbol interval is switched off (punctured or not transmitted) and in order to supplement the symbol energy of the lost data belonging to all the channels involved, the transmission power of all the channels whose data symbol transmission have been switched off can be increased at the corresponding interval in such an amount that is stipulated in the Communication Protocol.

As an example of multiplexing communication system, a mobile communication system IS-95 which is a prior art which has been laid open.

The digital and analog frequency division multiplexing (FDM) communication systems according to a prior art, communicate through allocation of an empty frequency allocation(FA) to a secondary communication station by the primary communication station at the time of a call establishment irrespective of the degree of channel activity and other secondary communication stations are allowed to utilize the available frequency channels released at the time of call termination.

The Time Division Multiplexing (TDM) communication systems according to a prior art, communicate through

allocation of an time slot amongst a plurality of time slots which have not been allocated to a secondary communication station by the primary communication station at the time of a call establishment irrespective of the degree of channel activity and other secondary communication stations are allowed to utilize the available time slots released at the time of call termination.

The Frequency Hopping Multiplexing (FHM) communication system according to a prior art, communicates between the primary and secondary communication stations through a prearranged frequency hopping pattern.

The Orthogonal Code Division Multiplexing (OCDM) communication system according to a prior art, communicates through allocation of an orthogonal code symbol within the orthogonal code which has not been allocated to a secondary communication station by the primary communication station at the time of a call establishment irrespective of the degree of channel activity, and other secondary communication stations are allowed to utilize the available orthogonal code symbol released at the time of call termination.

BACKGROUND ART

The embodiments of prior arts pertaining to multiplexing method(5) which have been laid open are described as below.

FIG. 1 illustrates the system according to the

embodiments of the prior arts and present invention. All communication channels from the primary communication station 101 to the secondary communication stations 111, 112, 113 are synchronized and also orthogonal to each other.

FIG. 2a is a block diagram of the transmitter of the primary communication station which corresponds to the common constituent parts in the embodiments of the prior arts and present invention, FIG. 2b is a block diagram of the transmitter of the primary communication station on traffic channel in the embodiments of the prior arts. The pilot channel 200 should exist per each Sub-Carrier (SC) because it is used as a channel estimation signal for the purpose of initial synchronization acquisition, tracking and coherent demodulation by the secondary communication station, as shown in FIG. 1, and shared by all the secondary communication stations in the area covered by the primary communication station. As illustrated in FIG. 2a, it also provides a phase reference for coherent demodulation by sending the known symbols. The synchronization channel 210 along with the pilot channel 200 is a one-way broadcasting channel that is broadcast to all the secondary communication stations in the area covered by the primary communication station, and the commonly required information by all the secondary communication stations are transmitted from the primary communication station (i.e., time information and the identifier of the primary communication station).

The data from the synchronization channel pass

through a convolution encoder 214, a symbol repeater for adjusting a symbol rate 216, a block interleaver 218 for converting bursty errors to random errors and a symbol repeater 219 for matching a transmitting data symbol rate and are then transmitted to a spreading and modulation block, shown in FIGs. 3a-3f. A paging channel 220 shown in FIG. 2a is a common channel used in case of an incoming message to the secondary communication station or for responding to a request of the secondary communication station. Multiple paging channels 220 can exist.

The data transmitted through the paging channel pass through a convolutional encoder 224, a symbol repeater 226 and a block interleaver 228 and passes through an exclusive OR gate 236 together with an output of a long code generator 232 generated by a long code mask 230. The data through the exclusive OR gate 236 is then transmitted to the spreading and modulation block of FIG. 3.

A traffic channel 240 in FIG. 2b is a channel dedicatedly allocated to each secondary communication station for use until the call is completed. When there are data to be transmitted to each secondary communication station, the primary communication station transmits the data through the traffic channel 240. The data from the traffic channel 240 passes through a cyclic redundancy check (CRC) bit attachment block 241 for detecting errors in a specific time unit, or frame, (e.g. 20ms in IS-95). A tail bit attachment block 242 is inserted into the traffic channel, all of which are

"0", and the data through the CRC 241 pass through a convolutional encoder 244 for ensuring to independently encoding the channel in a frame unit. The data then pass through a symbol repeater 246 for matching its transmitting symbol rate according to a transmitting data rate. After passing through the symbol repeater 246, the data pass through a block interleaver 248 for changing an error burst into a random error. The data passing through the block interleaver 248 are scrambled in a scrambler 256 using a pseudo-noise (PN) sequence, generated by passing an output of a long code generator 232 decimated in a decimator 234 by using a long code mask 250 generated by an electronic serial number (ESN) allocated to each secondary communication station.

A PCB (Power Control Bit) position extractor 258 extracts a position where a command for controlling transmission power from the secondary communication station is inserted in the PN sequence decimated in the decimator 234. A puncturing and inserting block 260 punctures an encoded data symbol corresponding to the inserting position of the power control command extracted by the PCB position extractor 258 among the data symbols scrambled in the scrambler 256 and inserts the power control command, then transmitting the power control command to the spreading and modulation block in FIG. 3.

According to the present invention, the location of the data symbol for multiplexing transmission hopping time can

also be determined by using the PN sequence decimated as shown above.

FIGs. 3a, 3b and 3c show an embodiment of a spreading and modulation block according to the prior art.

FIG. 3a corresponds to the commonly used IS-95 system employing BPSK (Binary Phase Shift Keying) as a data modulation method.

FIG. 3b shows the case for spreading I/Q channel transmitting data by separately employing a different orthogonal code symbol on each of I/Q channel.

FIG. 3c shows the spreading and modulation block employing QPSK (Quadrature Phase Shift Keying) as a data modulation method for transmitting double data rate in comparison to the method in FIG. 3a. FIG. 3c is adapted in the cdma2000® system, which is one of candidate techniques for the IMT-2000 system.

FIG. 3d shows the spreading and modulation block employing QPSK (Quadrature Phase Shift Keying) as a data modulation method for transmitting double data rate in comparison to the method in FIG. 3b.

FIG. 3e shows a spreading and modulation block, which employs QOC (Quasi-Orthogonal Code) used in cdma2000® system, which is one of candidate techniques for the IMT-2000 system.

FIG. 3f shows the case for spreading I/Q channel transmitting data by separately employing a different orthogonal code symbol on each of I/Q channel.

In FIG. 3a, signal converters 310, 330, 326, 346, 364 convert logical values “0” and “1” to physical signal “+1” and “-1” to be really transmitted. Each channel of FIG. 2 passes through the signal converters and is then spread in spreaders 312, 332 by an output of a Walsh code generator 362. Transmission power of each channel is adjusted in gain controllers 314, 334.

All channels from the primary communication station are spread in spreaders 312, 332 by an orthogonal Walsh function from the Walsh code generator 362 allocated to each channel fixedly. The channels are then gain-controlled in the gain controllers 314, 334 and then multiplexed 316, 336 based on orthogonal code division scheme. The multiplexed signals are scrambled at QPSK spreading and modulation blocks 318, 338 by a short PN sequence 324, 344 for the primary communication station identification. Low-pass filters (LPF) 320, 340 filter the spread and scrambled signals. The signal modulated by the carrier passes through a radio frequency (RF) processing block and is then transmitted through an antenna.

In FIG. 3b, signal converters 310, 330, 326, 346, 364, 365 convert logical values “0” and “1” into physical signal “+1” and “-1” to be really transmitted. Each channel of FIG. 2 passes through the signal converters and is then spread in spreaders 312, 332 by each output of two Walsh code generators 362, 363. Transmission power of each channel is adjusted in gain controllers 314, 334.

All channels from the primary communication station are spread in spreaders 312, 332 by an orthogonal Walsh function of the Walsh code generators 362, 363 allocated to each channel fixedly. The channels are then gain-controlled in the gain controllers 314, 334 and then are multiplexed 316, 336 based on the orthogonal code division scheme. The multiplexed signals are scrambled at QPSK scrambling blocks 318, 338 by a short PN sequence 324, 344 for identification of the primary communication station. Signals spread and scrambled are filtered by low-pass filters (LPF) 320, 340. The signal modulated by the carrier passes through a radio frequency (RF) processing block and is then transmitted through an antenna.

FIG. 3c is identical to FIG. 3a except the fact that, in order to transmit the signal generated in FIG. 2 to QPSK instead of BPSK, different information data are carried in an in-phase channel and a quadrature phase channel through a demultiplexer 390. Using the demultiplexer 390 and the signal converters 310, 330 enables QAM (Quadrature Amplitude Modulation) as well as QPSK.

FIG. 3d is identical to FIG. 3b except the fact that, in order to transmit the signal generated in FIG. 2 to QPSK instead of BPSK, different information data are carried in an in-phase channel and a quadrature phase channel through a demultiplexer 390.

FIG. 3e shows the case that a QOC mask is used for distinguishing a channel from the primary communication

station to the secondary communication stations in FIG. 3c. Orthogonality is not maintained in a code symbol group using different QOC masks but maintained in a code symbol group using the same QOC mask. Therefore, the present invention is applied to the orthogonal code symbol group using the same QOC mask, in which the orthogonality is maintained.

FIG. 3f like FIGs. 3b and 3d, is identical to FIG. 3e except the fact that, an independent Walsh code generator exists at I and Q channels in order to be able to spread I/Q channels transmitting data through a different orthogonal code symbol.

FIGs 4a, 4b and 4c is an example of signal diagram in order to explain a multiplexing method which transmits the signals by allocating orthogonal resources at each channel.

When a primary communication station communicates with its secondary communication stations, the transmission data rate transmitted to each secondary communication station can vary with respect to time. For instance, if the highest transmission rate per channel allocated to the secondary communication station by the primary communication station is a basic transmission rate (R), then the average transmission rate can be determined with a variety of forms such as R, R/2, R/4, ..., and 0, according to the amount of data transmitted from the primary communication station to the secondary communication station at each frame.

FIG. 4a shows the case for matching an instant

transmission rate at each frame with the average transmission rate and this method is used in orthogonal code division multiplexing communication system for a forward link such as IS-95.

FIG. 4b illustrates the method for matching an instant transmission rate with the basic transmission rate at each frame by filling up the empty parts with dummy information when the transmitting data at each frame is less than the basic transmission rate.

FIG. 4c shows the method for adjusting the average transmission rate at the corresponding frame according to a rate between the intervals which possess R and 0 as the transmission rates where the instant transmission rate is either a basic transmission rate (R) or 0 (No transmission). The method used in FIG. 4c is not the transmission symbol based ON/OFF like the present invention, but time slot based ON/OFF. The time slot which is a power control period, is used for controlling the average transmission rate at each frame and at the same time maintaining a reference signal amplitude for closed loop power control of a reverse link in IS-95 system. In the IS-95 reverse link, unlike the present invention, the orthogonality between the channels is not guaranteed.

In FIGs 4a, 4b and 4c, a primary communication station transmits a common pilot channel signal to the secondary communication stations in parallel, however, since the pilot channel is used as a reference for synchronization, channel

tracking, phase estimation and power control, the pilot channel signal can be transmitted using the time division multiplexing method similar to the Wideband CDMA (W-CDMA) system for IMT-2000 system. In this case, the pilot channel according to the pilot symbol or location of multiplexing is called in various terms including a Preamble, Mid-amble and Post-amble.

FIG. 4d illustrates the frequency division multiplexing method according to the prior arts. A different frequency band is used as a communication channel between the primary communication station and each secondary communication station. The frequency division multiplexing method according to the present invention includes the Orthogonal Frequency Division Multiplexing (OFDM) method of which has been extensively studied for a satellite broadcasting systems. In case of OFDM, the frequency band for each subcarrier channel is in an overlapped state which has not been completely separated. However, it can be included in the orthogonal resource of the present invention since the orthogonality between the subcarriers is guaranteed.

FIG. 4e illustrates the conventional time division multiplexing method such as the GSM system. The same frequency band is used as a communication channel between the primary communication station and each secondary communication station. However, each time slot within the frame is wholly allocated to the corresponding secondary communication station.

FIGs. 4f, 4g and 4h show an implementation of the frequency hopping method on the conventional frequency division multiplexing method, as shown in FIG. 4d, in order to improve the frequency diversity and security.

FIG. 4f shows the frequency hopping pattern on a time slot basis.

FIG. 4g shows a regular frequency hopping pattern based on a transmitting data symbol unit.

FIG. 4h shows an irregular frequency hopping based on a transmitting data symbol unit.

FIG. 4g illustrates a method that focuses on frequency diversity and FIG. 4h shows a method that emphasizes the security on frequency diversity and protection against the eavesdropping from any unauthorized receivers. In the frequency hopping multiplexing, there exists a fast frequency hopping multiplexing method based on a symbol and part-symbol unit as well as a slow frequency hopping multiplexing method based on a few symbol units.

The methods shown in FIGs. 4f, 4g and 4h can provide frequency diversity by implementing the time division multiplexing method in FIG. 4e. In reality, the use of the time slot and frequency hopping based on a frame unit for strengthening the frequency diversity instead of security enhancement in the second generation mobile communication system such as Global System for Mobile (GSM) is optional.

FIG. 4i illustrates the conventional orthogonal code division multiplexing such as IS-95, cdma2000® and W-CDMA.

secondary communication station at the time of a call establishment.

Second, as shown in FIG. 4e, using a frequency division multiplexing method which fixedly allocates a time slot of the primary communication station to a secondary communication station at the time of a call establishment.

Third, as shown in FIGs. 4f, 4g and FIG. 4h, allocating a controlled frequency hopping pattern to the secondary communication station in order to avoid a frequency selective fading at the time of a call establishment or using a total bandwidth consisted of several sub-carriers in a single secondary communication station at a given time and place like in a military use.

Fourth, as shown in FIG. 4i, spreading the channel to the secondary communication station by allocating an available orthogonal code symbol to the secondary communication station at the time of a call establishment.

Among the four methods described, the common point for the rest of three methods excluding the frequency hopping multiplexing is to fixedly allocate orthogonal resources (frequency, time, orthogonal code) to the secondary communication station by the primary communication station. The frequency hopping multiplexing is also used in applications with a sufficient amount of resources mainly for the purpose of security. Therefore, it is not subjected to an efficient use of the resources. Hence, in a case where this method is used, a fixed allocation of a limited orthogonal

data transmission delay and achieves a seamless handoff to adjacent cells. The present invention utilizes a statistical multiplexing called as multi-dimensional orthogonal code hopping multiplexing which takes frequency, time and orthogonal code as an orthogonal axis in case when the activity of the synchronized channels which maintains orthogonality is low or when the transmitting data rate of the channels vary at the lower rate than the basic transmission rate.

In order to accomplish the above objective, the present invention provides a multiplexing method and apparatus wherein orthogonal resources are pseudo-randomly allocated to the encoded data symbols on the basis of statistical characteristics required by the service to the channels with a data channel that generates a relatively low traffic or the channels whose real transmitting data rate varies below the allocated basic transmitting data rate. As a result, the channels are statistically multiplexed by distinguishing the channels through multi-dimensional orthogonal resource hopping patterns. In order to protect from a faulty reception due to the collision of the multi-dimensional orthogonal resource coordinates which may occur from the independent and pseudo-random hopping pattern for each secondary communication station, the transmitting encoded data symbols for all channels involved in the collision are compared, and the transmission is halted unless all the transmitting data coincide. At the same time, in order to

FIG. 4i illustrates a transmission signal diagram based on the orthogonal code division multiplexing (OCDM) method according to the prior arts (Fixed orthogonal code allocation for each channel).

FIG. 5 shows a configuration of a receiver of the secondary communication station based on the orthogonal code division multiplexing corresponding to a configuration of the transmitter in FIG. 4i.

FIG. 6 illustrates a common configuration of a receiver of the secondary communication station according to the embodiments of the prior arts and the present invention.

FIG. 7 shows a configuration of a receiver of the secondary communication station according to the embodiments of the prior arts.

FIG. 8 illustrates a common configuration of a receiver of the secondary communication station according to the embodiments of the prior arts and present invention.

FIG. 9a shows a configuration of a transmitter of the primary communication station with the multiple traffic channels that are orthogonal resource hopping multiplexed and common physical control channels for the traffic channels according to the embodiments of the present invention.

FIG. 9b illustrates a signal diagram of common physical control channel (CPCCH) according to the embodiments of the present invention.

FIG. 10a shows a configuration of transmitter of the primary communication station based on the multi-

(corresponding to FIG. 3f).

FIG. 11 shows a configuration of a multi-dimensional hopping pattern generator according to the embodiments of the present invention.

FIG. 12a illustrates an example of sub-carrier group for frequency hopping according to the embodiments of the present invention (orthogonal resource = frequency).

FIG. 12b shows a sub-carrier synthesizer according to the output of frequency hopping pattern generator according to the embodiments of the present invention.

FIG. 12c illustrates an example data symbol position for transmission time hopping based on a symbol unit according to the embodiments of the present invention (orthogonal resource = time, “1”= ON, “0” = OFF).

FIG. 12d shows a configuration of data symbol position selector (or buffer) according to the output of time hopping pattern generator in the transmitter of the primary communication station in the embodiments of the present invention.

FIG. 12e illustrates a configuration of orthogonal Gold code generator according to the orthogonal code hopping patterns in the embodiments of the present invention (orthogonal resource = orthogonal Gold code).

FIG. 12f shows a tree-structured orthogonal Walsh code according to several spreading factors (orthogonal resource = orthogonal Walsh code).

FIG. 12g illustrates a configuration of orthogonal Walsh

code generator according to the orthogonal code hopping patterns in the embodiments of the present invention (orthogonal resource = orthogonal Walsh code).

FIG. 12h shows a configuration of symbol position selector (or buffer) according to the output of time hopping pattern generator in the transmitter of the second communication in the embodiments of the present invention.

FIG. 13a illustrates a configuration of receiver of the secondary communication station based on the multi-dimensional orthogonal resource hopping multiplexing method according to the embodiments of the present invention in FIG. 10a.

FIG. 13b shows a configuration of receiver of the secondary communication station based on the multi-dimensional orthogonal resource hopping multiplexing method according to the embodiments of the present invention in FIG. 10b.

FIG. 13c illustrates a configuration of receiver of the secondary communication station based on the multi-dimensional orthogonal resource hopping multiplexing method according to the embodiments of the present invention in FIG. 10c.

FIG. 13d shows a configuration of receiver of the secondary communication station based on the multi-dimensional orthogonal resource hopping multiplexing method according to the embodiments of the present invention in FIG. 10d.

FIG. 13e illustrates a configuration of receiver of the secondary communication station based on the multi-dimensional orthogonal resource hopping multiplexing method according to the embodiments of the present invention in FIG. 10e.

FIG. 13f shows a configuration of receiver of the secondary communication station based on the multi-dimensional orthogonal resource hopping multiplexing method according to the embodiments of the present invention in FIG. 10f.

FIG. 14a illustrates a transmission signal diagram from the primary communication station for each frame according to the embodiments of the conventional method.

FIG. 14b shows a transmission signal diagram from the primary communication station for each frame according to the embodiments of the present invention.

FIG. 14c illustrates a (regularly time-hopped) transmission signal diagram from the primary communication station in a frame (statistically coarse frame) whose transmission rate is below the basic transmission rate (R) according to the embodiments of the present invention.

FIG. 14d shows a (irregularly time-hopped) transmission signal diagram from the primary communication station in a statistically coarse frame according to the embodiments of the present invention.

FIG. 14e illustrates a (irregularly time-hopped) transmission signal diagram from the primary communication

station by a frequency hopping multiplexing (FHM) in a statistically coarse frame according to the embodiments of the present invention.

FIG. 14f shows illustrating a collision case (the square surrounded by double-line is a collided data symbol) which occurs due to a simultaneous selection of through multiple channels of the multi-dimensional hopping patterns that are represented in a two-dimensional coordinate in FIG. 14e (transmission time, sub-carrier).

FIG. 14g illustrates illustrating the final process to determine whether to transmit or not by comparing the transmitting data symbols where collisions occur, as shown in FIG. 14f.

FIG. 14h shows a diagram of regularly time-hopped transmission signal from the primary communication station based on symbol units in a statistically coarse frame according to the embodiment of the present invention.

FIG. 14i illustrates a diagram of irregularly time-hopped transmission signal from the primary communication station based on symbol units in a statistically coarse frame according to the embodiment of the present invention.

FIG. 14j illustrates a collision case (the square surrounded by double line is a collided data symbol) that occurs due to a simultaneous selection through multiple channels of the multi-dimensional hopping patterns that are represented in a one-dimensional coordinate in FIG. 14i (transmission time (or position of data symbol)).

FIG. 14k shows the final process to determine whether to transmit or not (the squares filled with black color indicate a transmission and the empty squares surrounded by dashed line indicates no transmission) by comparing the transmitting data symbols where collisions occur, as shown in FIG. 14j.

FIG. 14l illustrates a diagram of transmission signal from the primary communication station by the orthogonal code hopping multiplexing method in a basic transmission rate (R) frame (statistically dense frame) according to the embodiment of the present invention.

FIG. 14m shows a diagram of transmission signal from the primary communication station by the time division multiplexing based on slot units and orthogonal code hopping multiplexing in a statistically coarse frame according to the present invention.

FIG. 14n illustrates a collision case (the square surrounded by double line is a collided data symbol) that occurs due to a simultaneous selection through multiple channels of the multi-dimensional hopping patterns that are represented in a one-dimensional coordinate in FIG. 14m (transmission time, orthogonal code).

FIG. 14o shows the final process to determine whether to transmit or not by comparing the transmitting data symbols where collisions occur, as shown in FIG. 14n (the squares filled with black color indicate transmission and the empty squares surrounded by dashed line indicate no transmission).

FIG. 14p illustrates a transmission signal diagram (the

first data symbol of a frame is located at an identical position) from the primary communication station by a regular and periodic time division multiplexing based on a symbol unit and orthogonal code hopping multiplexing in a statistically coarse frame according to the present invention.

FIG. 14q shows a collision case (the square surrounded by double line is a collided data symbol) that occurs due to a simultaneous selection through multiple channels of the multi-dimensional hopping patterns that are represented in a two-dimensional coordinate in FIG. 14p (transmission time, orthogonal code symbol).

FIG. 14r shows the final process to determine whether to transmit or not (the squares filled with black color indicate a transmission and the empty squares surrounded by dashed line indicate no transmission) by comparing the transmitting data symbols where collisions occur, as shown in FIG. 14q.

FIG. 14s shows a transmission signal diagram (the first data symbol of a frame is located at a skewed position) of the primary communication station by a regular and periodic time division multiplexing based on a symbol unit and orthogonal code hopping multiplexing in a statistically coarse frame according to the present invention.

FIG. 14t illustrates a collision case (the square surrounded by double line is a collided data symbol) which occurs due to a simultaneous selection through multiple channels of the multi-dimensional hopping patterns that are represented in a two-dimensional coordinate in FIG. 14s

(transmission time, orthogonal code).

FIG. 14u shows the final process to determine whether to transmit or not (the squares filled with black color indicate a transmission and the empty squares surrounded by dashed line represent no transmission) by comparing the transmitting data symbols where collisions occur, as shown in FIG. 14t.

FIG. 14v illustrates a diagram of transmission signal from the primary communication station by an irregular and periodic time division multiplexing based on a symbol unit and orthogonal code hopping multiplexing in a statistically coarse frame according to the present invention.

FIG. 14w illustrates a collision case (the square surrounded by double line is a collided data symbol) which occurs due to a simultaneous selection through multiple channels of the multi-dimensional hopping patterns that are represented in a two-dimensional coordinate in FIG. 14v (transmission time, orthogonal code).

FIG. 14x shows the final process to determine whether to transmit or not (the squares filled with black color indicate a transmission and the empty squares surrounded by dashed line indicate no transmission) by comparing the transmitting data symbols where collisions occur, as shown in FIG. 14w.

FIG. 15 in case of FIGs. 14g, 14o, 14r, 14u and 14x illustrates an increase in transmission power of the primary communication station for a specific interval after the data symbols which are not transmitted in order to satisfy the required quality and to compensate for the average received

energy required by the channel decoder when the transmission is temporarily halted in a collision interval of multi-dimensional hopping patterns.

FIG. 16 shows that the puncturing of encoded data symbol due to a collision of multi-dimensional hopping patterns and an inconsistency of data symbols is operated independently for each transmission antenna beam from the primary communication station.

* Description of the numeric on the main parts of the drawing

380: Multi-dimensional (Orthogonal Resource) Hopping Pattern Generator

382: Orthogonal Code Generator according to multi-dimensional hopping patterns

384, 386: Hopping pattern Collision Detector, Data Symbol Comparator and Controller

388: Frequency synthesizer according to multi-dimensional hopping pattern

385, 387: Transmission Power Control Apparatus using the Controller

392, 393: Symbol Position Selector (or Buffer) according to Multi-dimensional Hopping Pattern

BEST MODE FOR CARRYING OUT THE INVENTION

Hereinafter, preferred embodiments of the present

invention will be described in detail with reference to the accompanying drawings.

In this application, the same reference numbers are used for components similar to the prior art and only modified or added components in comparison with the prior art are described for the present invention in detail.

The orthogonal code hopping multiplexing (OCHM) according to the present invention is to communicate by selecting an orthogonal code symbol with respect to the one-dimensional hopping pattern agreed between the primary communication station and a secondary communication station. In case of a collision, if the agreed one-dimensional hopping pattern between the primary communication station and a second communication is independent, all the data symbols belonging to the channels related to the collision are compared and transmitted when all of them are identical data symbols. Otherwise, the corresponding symbols are not transmitted by puncturing and the punctured parts of the data symbols are recovered from the receiver using a channel decoder (Korean Patent of Application Number 10-1999-032187, "Method and apparatus for orthogonal code hopping multiplexing communications"). The present invention is a statistical multiplexing method that generalizes the orthogonal code hopping method to orthogonal resource hopping of all the orthogonal resources.

In the embodiments of the present invention, a primary communication station and the secondary communication

station correspond to a base station and a mobile station, respectively, in the existing commercial mobile communication system. A single primary communication station communicates with a plurality of the secondary communication stations and the present invention provides a statistical multiplexing method that can be implemented in a group of synchronized channels with orthogonality from the primary communication station to the secondary communication station. Like Quasi-Orthogonal Code (QOC) that is adopted in the cdma2000® method which is one of candidate technologies for the next generation mobile communication system and Multi-Scrambling Code (MSC) adopted in the W-CDMA method, the method from the present invention can be independently implemented within the system where orthogonalilty is maintained in each channel group. Also, when the channels from the primary communication station are classified into a number of channel groups which possess the same transmission antenna beam like sectorization, switched beam or smart antenna system, the present invention can be independently implemented in each channel group.

FIG. 9a shows a configuration for multi-dimensional orthogonal resource hopping multiplexing for bursty channels and this configuration is identical except for the fact that puncturing and insertion of transmission control commands for the secondary communication station. For communication, there exist a two-way and one-way communication and for the

one-way communication, there is no need for transmitting transmission power control commands to the secondary communication station. However, for two-way communication, there is a need for transmission power control in order to maximize system capacity through efficient power control. For fast processing, power control commands are not channel-encoded generally. For a pseudo-random orthogonal code hopping pattern, a collision between two different channels is inevitable. Hence, the power control command should be transmitted through a collision-free channel. For this purpose, the concept of common power control channel, from the cdma2000® method which is one of the candidates for IMT 2000 system, can be adopted in this specification and called here Common Physical Control CHannel (CPCCH).

The Common Physical Control Channel like the pilot channel previously mentioned, is spread through a separate orthogonal code symbol and transmits a physical class control command by time division multiplexing for a plurality of the secondary communication stations. The location for a power control command for each secondary communication station is allocated at the establishment of a call.

FIG. 9a illustrates an embodiment of the common physical control channels for controlling 24 secondary communication stations based on IS-95 system as an example. In case when the channel varies below the basic transmission rate (R) from the primary communication station to the secondary communication station and the information is

transmission within the buffers is determined according to the input values, as shown in FIG. 12c.

In FIG. 12c, “1” indicates the existence of transmitting data and “0” indicates the absence of transmitting data.

FIG. 12d shows an example of an implementation when the number of probable positions for the existence of transmitting data is 16 in FIG. 12c.

The transmission time hopping as a multi-dimensional hopping multiplexing method is carried out in transmission symbol unit rather than in frame or time slot by taking an instant transmission rate as the basic transmission rate (R) in order to maximize the statistical multiplexing and to conveniently track the communication channels to the secondary communication station. The hopping is carried out in symbol unit. It is relatively convenient to track the changes of the channels in the secondary communication station since the transmission symbols are distributed evenly in probability within a frame.

The orthogonal codes generated from the orthogonal code generator 382 can either be orthogonal gold codes that are generated by the orthogonal gold code generator in FIG. 12e or any other orthogonal codes that maintain orthogonality such as the Orthogonal Variable Spreading Factor of a hierarchical configuration that becomes a Walsh code with respect to a specified spreading factor.

Among the outputs of the multi-dimensional hopping pattern generator 380, if the coordinates of the orthogonal

code axis is fixed, then this is an orthogonal code division multiplexing method which is identical to the conventional method. By separating one orthogonal code into two orthogonal symbol groups, one orthogonal code symbol group is used for an orthogonal code division by a fixed allocation and the other is used for an orthogonal code hopping multiplexing by the hopping patterns. One of the two divided orthogonal symbol groups is orthogonal code hopping multiplexed using randomly selected patterns in order to avoid collisions between the hopping patterns and the other orthogonal code symbol group is orthogonal code hopping multiplexed by the statistical multiplexing using independent hopping patterns between the channels with a possibility of hopping pattern collisions.

In both cases, the former is allocated when either the transmitting data is important or the activity of channel is high, and the latter can gain a statistical advantage by allocating to a channel that generates relatively bursty traffic.

In case that hierarchical orthogonal codes which assist the variable spreading advantage are used as spreading codes shown in FIG. 12f, it is convenient to divide an orthogonal code into an orthogonal code symbol group that consists of child code symbols which possess the same parent symbols 391, 395 such as “01” or “0110” when dividing the orthogonal codes.

As briefly mentioned previously, for the case when the multi-dimensional hopping pattern generator 380 generates

multi-dimensional hopping patterns randomly in order for two different channels not to select an identical resource at the same time for each channel, no collision occurs. However, with this method, no multi-dimensional hopping patterns can be determined by the secondary communication station and the multi-dimensional hopping patterns should be allocated at the time of a call establishment by the primary communication station. Also, the number of multi-dimensional hopping patterns that can be allocated by the primary communication station is constrained by the number of the orthogonal resources and in case when a handoff occurs at an adjacent cell, a new multi-dimensional hopping pattern needs to be allocated from the adjacent cell.

The purpose of allocating multi-dimensional hopping patterns between the channels toward the secondary communication station without any collisions is not for statistical multiplexing but for attaining the gain from the diversity.

If the channels toward the secondary communication station have a high activity with statistically dense or non-bursty traffic, then it is more efficient to operate without any statistical multiplexing. However, according to the service characteristics, if channels toward the secondary communication station have a low activity with statistically sparse or bursty traffic, the resources could be wasted. Therefore, independent multi-dimensional hopping patterns are generated in order to attain the gain from statistical

multiplexing and time diversity according to the data activity of each channel.

As a result, collisions inevitably occur between the multi-dimensional hopping patterns where two different channels select an identical multi-dimensional resource coordinate at the same time. Hence, in order to resolve this problem in the present invention, collisions between the hopping patterns are determined with a collision detector and controller 384, 386 by receiving all the hopping patters and data symbols to be transmitted for all channels.

All the multi-dimensional hopping patterns for each secondary communication station are generated within the primary communication station and all the data to be transmitted in each secondary communication station pass through the primary communication station. Therefore, whether the multi-dimensional hopping patterns collide or not and whether the transmitting data is identical or not can be ascertained.

All the data symbols from all the channels, corresponding to the case when multi-dimensional hopping patterns collide, are compared and if all the transmitting data symbols are identical, then the data symbols during the colliding interval are transmitted. This is because no errors occur during a channel decoding process for corresponding secondary communication station. If one of the symbols is not identical then the data symbols between the colliding interval of the corresponding channel are not transmitted. To be more

specific, according to the results from the collision detector and comparator 384, 386, the input for multiplier 385 and 387 becomes "+1" or "0". The transmission is off for the interval where the input for the multiplier is "0". In order to compensate for a lack of the average receiving energy of the secondary communication station required by the puncturing of the spread data symbols to satisfy the quality, the transmission power of the primary communication station is increased by controlling the gain of amplifiers 315, 335 of the corresponding channel in an amount and interval which is given as a system parameter like 1072 and 1074 in FIG. 15. Separately, the transmission power control of the primary communication station to the secondary communication stations can also be carried out according to the conventional method.

FIG. 10b shows an implementation method of the present invention to the embodiment of the conventional method in FIG. 3b.

It is identical to FIG. 10a except that independent multi-dimensional hopping patterns are generated at Identical Phase channel (I) and Quadrature Phase channel (Q) of the multi-dimensional hopping pattern generator 380. For the statistical multiplexing using multi-dimensional orthogonal resource hopping as proposed in the present invention, a multi-dimensional hopping pattern generator 380 and a collision detector and controller 384, 385 that determines the independent collision and transmission status for the I/Q

channels are required.

FIG. 10c shows a diagram for implementing the present invention to the embodiment of the conventional method in FIG. 3c.

It is identical to FIG. 10a except that the transmitting data to the I and Q channels are different since it modulates QPSK data unlike FIG. 10a which modulates BPSK data.

FIG. 10d shows a diagram for implementing the present invention to the embodiment of the conventional method in FIG. 3d

It is identical to FIG. 10c except that independent multi-dimensional hopping patterns are generated at the Identical Phase channel (I) and Quadrature Phase channel (Q) of the multi-dimensional hopping pattern generator 380. For the statistical multiplexing using multi-dimensional orthogonal resource hopping as proposed in the present invention, a multi-dimensional hopping pattern generator 380 and a collision detector and controller 384, 385 that determines the independent collision and transmission status for the I/Q channels are required.

FIG. 10e illustrates a diagram for implementing the present invention to the embodiment of the conventional method in FIG. 3e.

It is identical to FIG. 10c except that it uses a Quasi-Orthogonal Code (QOC).

FIG. 10f shows a diagram for implementing the present invention to the embodiment of the conventional method in

FIG. 3f.

It is identical to FIG. 10d except that it uses a Quasi-Orthogonal Code (QOC).

In FIG. 13a the signals from the primary communication station, which are received from an antenna, are demodulated 510, 530 by a frequency synthesizer 588 that is controlled by a multi-dimensional hopping pattern generator 580 and pass through a low power filter 512, 532. The low power filtered signals are descrambled 522, 542 using the scrambling codes 520, 540 which are identical to the receiver side and the orthogonal code symbols, generated 582 according to the coordinates of the orthogonal code axis which are delivered by the multi-dimensional hopping pattern generator 580 which is synchronized with the transmitter of the primary communication station, are multiplied 514, 534 and despread by integrating 516, 536 for the corresponding symbol interval. With the despread signals a non-coherent demodulation is carried out by compensating for the phase difference through a channel estimator. The compensated data symbols are delivered to the buffers 592, 593 by matching them with the coordinates of the transmission time axis of the multi-dimensional hopping pattern generator.

Since the transmitter for the primary communication station in FIG.10a performs a BPSK data modulation, the corresponding transmitter for the secondary communication station in FIG. 13a adds the received data from the I and Q channels that possess identical information. If independent

secondary communication station for the orthogonal resource hopping multiplexing method according to the present invention in FIG. 10e. It is identical to FIG. 13e except that the received signal is despreading by using a quasi-orthogonal code 566.

FIG. 13f illustrates a configuration of the receiver in the secondary communication station for the orthogonal resource hopping multiplexing method according to the present invention in FIG. 10f. It is identical to FIG. 13e except that there exist an independent code generator 582, 584 for each of the I and Q channels.

FIG. 14 shows a concept diagram for a transmission signal from the primary communication station according to the embodiment of the present invention.

FIG. 14a is identical to the transmission signal diagram in the primary communication station for each frame according to the embodiment of the conventional method in FIG. 4a. The transmission rate for each frame for the channels from the primary communication station to the second communication varies below the basic transmission rate (R) like 920, 930 according to the service characteristics or repeats transmission(ON) and no transmission (OFF) at the basic transmission rate (R) like 940,950. The channels like 920, 930 can be represented in a channel activity diagram. In the present invention, a transmission time hopping multiplexing can be applied to Channels 920, 930, as taken in Channels 924, 934 in FIG. 14b according to the transmitting

data rate for each frame. The transmission time hopping is implemented with the same method in FIG. 12d.

FIGs. 14c and 14d illustrate how hopping transmission time can be determined in reality with respect to the transmitting data rate for each frame. FIG. 14c shows a regular and periodic hopping. FIG. 14d illustrates an irregular and arbitrary hopping. FIG. 14c is advantageous for time diversity and channel tracking but is inappropriate for statistical multiplexing.

The method in FIG. 14d is useful for statistical multiplexing although a collision may occur if independent multi-dimensional hopping patterns are used for each frame.

FIG. 14e shows a method which takes a Frequency Hopping Multiplexing Method (FHM) and a Time Hopping Multiplexing Method in parallel in a statistically sparse frame according to the embodiment of the present invention. The secondary communication station can be distinguished by the pattern in square.

FIG. 14f illustrates a collision case which occurs due to a simultaneous selection through multiple channels of the multi-dimensional hopping patterns that are represented in a two-dimensional coordinate in FIG. 14e (transmission time, sub-carrier). The squares whose boundary is represented by a paired dot line indicate the location of data symbols where multi-dimensional hopping patterns collide and the squares whose boundary is represented by a single dot line indicate the location of data symbols where no collision occurs.

FIG. 14g shows the final process to determine whether to transmit or not by comparing the transmitting data symbols where collisions occur, as shown in FIG. 14f. The squares filled with black color indicate transmission even though collisions among multi-dimensional hopping patterns occur. All data symbols of the channels involved in the collisions are identical and the empty squares surrounded by dashed line indicate no transmission since all data symbols of the channels involved in the collisions are not identical.

FIG. 14h shows a diagram of transmission signal from the primary communication station by a time division multiplexing method based on symbol units in a statistically sparse frame according to the embodiment of the present invention. It is a time division multiplexing scheme based on symbol units that are evenly distributed in a frame unlike a time division multiplexing scheme based on slot units that are concentrated between a specific interval, as shown in FIG. 4e. Therefore, time diversity can be attained. When the hopping patterns in an example embodiment of the present invention are periodic and used for diversity rather than statistical multiplexing, there exist no channel independence toward the secondary communication stations, and at the time of a call establishment the result of allocation from the primary communication station to the other secondary communication stations should be referenced. Hence, the time division multiplexing based on symbol units in FIG. 14h is advantageous when the instantaneous transmission rate is

fixed.

FIG. 14i unlike FIG. 14h, illustrates a pseudo-random selection of a transmitting data symbol interval of the channel toward the secondary communication station in order to attain statistical multiplexing. The transmission time hopping patterns in the secondary communication station are independent.

FIG. 14j shows a collision case which occurs due to a simultaneous selection through multiple channels of the multi-dimensional hopping patterns that are represented in a one-dimensional coordinate in FIG. 14i (transmission time). The squares whose boundary is represented by a paired dot line indicate the location of data symbols where multi-dimensional hopping patterns collide and the squares whose boundary is represented by a single dot line indicate the location of data symbols where no collision occur.

FIG. 14k illustrates the final process to determine whether to transmit or not by comparing the transmitting data symbols where collisions occur in FIG. 14j. The squares filled with black color indicate a transmission even though collisions among multi-dimensional hopping patterns occur, all data symbols of the channels involved in the collisions are identical and the empty squares surrounded by dashed line indicate no transmission since all data symbols of the channels involved in the collisions are not identical.

FIG. 14l illustrates a special case orthogonal code hopping multiplexing where an orthogonal code that spreads

the transmitting data symbol band of the channel toward the secondary communication station is pseudo-randomly selected in order to attain statistical multiplexing. The orthogonal code hopping patterns toward the secondary communication station are independent. This method is explained in detail in the previous filed patent application on an orthogonal code hopping multiplexing method and apparatus (Korean patent of application number 10-1999-0032187) by the same inventors.

FIG. 14m shows a diagram of transmission signal to the secondary communication station where the time division multiplexing based on slot units according to the present invention and the orthogonal code hopping multiplexing coexist. In order to attain statistical multiplexing, the transmission time slots for the channel toward the secondary communication station and the orthogonal code symbols for spreading each transmitting data symbol are pseudo-randomly selected. The two-dimensional hopping patterns (transmission time, orthogonal code) are used for each secondary communication station.

FIG. 14n illustrates a collision case which occurs due to a simultaneous selection through multiple channels of the multi-dimensional hopping patterns that are represented in a one-dimensional coordinate in FIG. 14m (transmission time, orthogonal code). The squares whose boundary is represented by a paired dot line indicate the location of data symbols where multi-dimensional hopping patterns collide and the squares whose boundary is represented by a single dot line

indicate the location of data symbols where no collision occurs.

FIG. 14o shows the final process to determine whether to transmit or not by comparing the transmitting data symbols where collisions occur in FIG. 14n. The squares filled with black color indicate transmission even though collisions among multi-dimensional hopping patterns occur, all data symbols of the channels involved in the collisions are identical and the empty squares surrounded by dashed line indicate no transmission since all data symbols of the channels involved in the collisions are not identical.

FIG. 14p illustrates a diagram of transmission signal from the primary communication station where the time division multiplexing in FIG. 14h and the orthogonal code hopping multiplexing in FIG. 14l coexist. As mentioned previously, even if FIG. 14h shows a configuration where no statistical multiplexing gain is attained, by implementing the orthogonal code hopping multiplexing method in FIG. 14l, a statistical multiplexing is attained. Irrespective of the transmission rate at each channel, the location of the first transmission symbols toward all secondary communication stations are identical. The orthogonal code symbols for band spreading of each transmitting data symbol toward the secondary communication station are pseudo-randomly selected. The first hopping patterns (orthogonal code) toward the secondary communication station are independent.

FIG. 14q shows a collision case that occurs due to a simultaneous selection through multiple channels of the

multi-dimensional hopping patterns that are represented in a one-dimensional coordinate in FIG. 14p (orthogonal code). The squares whose boundary is represented by a paired dot line indicate the location of data symbols where multi-dimensional hopping patterns collide and the squares whose boundary is represented by a single dot line indicate the location of data symbols where no collision occur.

FIG. 14r illustrates the final process to determine whether to transmit or not by comparing the transmitting data symbols where collisions occur, as shown in FIG. 14q. The squares filled with black color indicate transmission even though collisions occur among multi-dimensional hopping patterns, all data symbols of the channels involved in the collisions are identical and the empty squares surrounded by dashed line indicate no transmission since all data symbols of the channels involved in the collisions are not identical.

FIG. 14s shows a variation on time division and orthogonal code hopping multiplexing in FIG. 14p. The primary communication station allocates the locations of the first data symbol to the secondary communication station skewed in order to maintain the balance of the transmission power. Like FIG. 14p, the orthogonal code symbols for spreading each transmitting data symbol for the channel toward the secondary communication station are pseudo-randomly selected. The one-dimensional hopping patterns for the second communication (orthogonal code) are independent.

FIG. 14t illustrates a collision case that occurs due to a

simultaneous selection through multiple channels of the multi-dimensional hopping patterns that are represented in a one-dimensional coordinate in FIG. 14s (orthogonal code). The squares whose boundary is represented by a paired dot line indicate the location of data symbols where multi-dimensional hopping patterns collide and the squares whose boundary is represented by a single dot line indicate the location of data symbols where no collision occur.

FIG. 14u shows the final process to determine whether to transmit or not by comparing the transmitting data symbols where collisions occur, as shown in FIG. 14t. The squares filled with black color indicate transmission even though collisions occur among multi-dimensional hopping patterns, all data symbols of the channels involved in the collisions are identical and the empty squares surrounded by dashed line indicate no transmission since all data symbols of the channels involved in the collisions are not identical.

FIG. 14v illustrates a diagram of transmission signal from the primary communication station where the time division multiplexing in FIG. 14i and the orthogonal code hopping multiplexing in FIG. 14l coexist. It is a combined statistical multiplexing method where it attains a statistical multiplexing gain through the time hopping multiplexing in FIG. 14i and at the same time, by implementing the orthogonal code hopping multiplexing method in FIG. 14l, statistical multiplexing is attained. The orthogonal code symbols for band spreading of each transmitting data symbol

toward the secondary communication station are pseudo-randomly selected. The first hopping patterns (orthogonal code) toward the secondary communication station are independent. The transmission time within a frame and the orthogonal code symbols for a band-spreading of each transmitting data symbol for the channel toward the secondary communication station are pseudo-randomly selected. The two-dimensional hopping patterns for the second communication (orthogonal code, orthogonal code) are independent.

FIG. 14w shows a collision case which occurs due to a simultaneous selection through multiple channels of the multi-dimensional hopping patterns that are represented in a one-dimensional coordinate in FIG. 14v (transmission time, orthogonal code). The squares whose boundary is represented by a paired dot line indicate the location of data symbols where multi-dimensional hopping patterns collide and the squares whose boundary is represented by a single dot line indicate the location of data symbols where no collision occur.

FIG. 14x illustrates the final process to determine whether to transmit or not by comparing the transmitting data symbols where collisions occur, as shown in FIG. 14w. The squares filled with black color indicate transmission even though collisions occur for multi-dimensional hopping patterns, all data symbols of the channels involved in the collisions are identical and the empty squares surrounded by dashed line indicate no transmission since all data symbols of

frame / basic transmission rate)

π_i = Probability of data symbol i to be transmitted where $i \in \{0, 1, 2, \ldots, s-1\}$ and s = Number of data symbols

Example) For 8PSK, s = 8

For 16QAM, s = 16

1)Frequency Hopping Multiplexing

Assumption: c_1 = Total number of sub-carriers of frequency axis in multi-dimensional hopping patterns

(1) Collision Probability of Hopping Patterns

[Equation 1]

$$\sum_{N=2}^{M}\left\{1-\left(1-\frac{1}{c_1}\right)^{N-1}\right\}\binom{M-1}{N-1}\alpha^{N-1}(1-\alpha)^{M-N}$$

(2) Symbol Punctuation Probability

[Equation 2]

$$\sum_{N=2}^{M}\left[\sum_{i=0}^{s-1}\left\{1-\left(1-\frac{1-\pi_i}{c_1}\right)^{N-1}\right\}\cdot\pi_i\right]\binom{M-1}{N-1}\alpha^{N-1}(1-\alpha)^{M-N}$$

(3) Symbol Punctuation Probability when all π_i's are identical.

[Equation 3]

$$\sum_{N=2}^{M}\left\{1-\left(1-\frac{1-\frac{1}{s}}{c_1}\right)^{N-1}\right\}\binom{M-1}{N-1}\alpha^{N-1}(1-\alpha)^{M-N}$$

(3) Transmission Time (or Symbol Position) Hopping multiplexing

Assumption: c_2 = Total number of available symbol positions in multi-dimensional hopping patterns

(1) Collision Probability of Hopping Patterns

[Equation 4]

$$\sum_{N=2}^{M}\left\{1-\left(1-\frac{1}{c_2}\right)^{N-1}\right\}\binom{M-1}{N-1}\alpha^{N-1}(1-\alpha)^{M-N}$$

(2) Symbol Punctuation Probability

[Equation 5]

$$\sum_{N=2}^{M}\left[\sum_{i=0}^{s-1}\left\{1-\left(1-\frac{1-\pi_i}{c_2}\right)^{N-1}\right\}\cdot\pi_i\right]\binom{M-1}{N-1}\alpha^{N-1}(1-\alpha)^{M-N}$$

(3) Symbol Punctuation Probability when all π_i's are identical

[Equation 6]

$$\sum_{N=2}^{M}\left\{1-\left(1-\frac{1-\frac{1}{s}}{c_2}\right)^{N-1}\right\}\binom{M-1}{N-1}\alpha^{N-1}(1-\alpha)^{M-N}$$

(4) Orthogonal Code Hopping Multiplexing

Assumption: c_3 = Total number of orthogonal code symbols in multi-dimensional hopping patterns

(1) Collision Probability of Hopping Patterns

[Equation 7]

$$\sum_{N=2}^{M}\left\{1-\left(1-\frac{1}{c_3}\right)^{N-1}\right\}\binom{M-1}{N-1}\alpha^{N-1}(1-\alpha)^{M-N}$$

(2) Symbol Punctuation Probability

[Equation 8]

$$\sum_{N=2}^{M}\left[\sum_{i=0}^{s-1}\left\{1-\left(1-\frac{1-\pi_i}{c_3}\right)^{N-1}\right\}\cdot\pi_i\right]\binom{M-1}{N-1}\alpha^{N-1}(1-\alpha)^{M-N}$$

(4) Symbol Punctuation Probability when all π_i's are identical

[Equation 9]

$$\sum_{N=2}^{M}\left\{1-\left(1-\frac{1-\frac{1}{s}}{c_3}\right)^{N-1}\right\}\binom{M-1}{N-1}\alpha^{N-1}(1-\alpha)^{M-N}$$

(5) Frequency, Transmission Time, Orthogonal Code Hopping Multiplexing

Assumption:

c_1= Total number of sub-carriers of frequency axis in multi-dimensional hopping patterns

c_2= Total number of symbol positions of time axis in multi-dimensional hopping patterns

c_3= Total number of orthogonal code symbols of orthogonal code axis in multi-dimensional hopping patterns

(1) Collision Probability of Hopping Patterns

[Equation 10]

$$\sum_{N=2}^{M}\left\{1-\left(1-\frac{1}{c_1+c_2+c_3}\right)^{N-1}\right\}\binom{M-1}{N-1}\alpha^{N-1}(1-\alpha)^{M-N}$$

(1) Symbol Punctuation Probability

[Equation 11]

$$\sum_{N=2}^{M}\left[\sum_{i=0}^{s-1}\left\{1-\left(1-\frac{1-\pi_i}{c_1+c_2+c_3}\right)^{N-1}\right\}\cdot\pi_i\right]\binom{M-1}{N-1}\alpha^{N-1}(1-\alpha)^{M-N}$$

(2) Symbol Punctuation Probability when all π_i's are identical

[Equation 12]

$$\sum_{N=2}^{M}\left\{1-\left(1-\frac{1-\frac{1}{s}}{c_1+c_2+c_3}\right)^{N-1}\right\}\binom{M-1}{N-1}\alpha^{N-1}(1-\alpha)^{M-N}$$

FIG. 15, like FIGs. 14g, 14o, 14r, 14u, and 14x illustrates an increase of transmission power of the primary communication station for a specific interval after the data symbols which are not transmitted in order to satisfy the required quality and to compensate for the average receiving energy required by the channel decoder when the transmission is halted in a collision interval of multi-dimensional hopping patterns.

Due to the collision of multi-dimensional hopping patterns and the inconsistency of transmission data symbols, transmission is off in a channel group that exists in the same transmission antenna beam toward the primary communication station. When a smart antenna like in FIG. 16 whose transmission antenna beams 1120, 1130, 1140 toward the primary communication station exist in plurality, even though the hopping patterns collide, the transmission for the channels 1132, 1142, 1144 in the transmission antenna beams 1130, 1140 in a collision interval is not stopped.

As can be seen from the embodiment of the present invention, when the multi-dimensional orthogonal resource hopping multiplexing is carried out by pseudo-random hopping patterns, a channel coding scheme in the transmission side and a channel decoding scheme in the

receiver's side are absolutely needed in order to recover the lost data during a lost interval from the receiver's side because the transmission data can be punctured and not transmitted during the interval where multi-dimensional hopping patterns collide.

The detailed explanation on the embodiments of the present invention has been focused on wireless mobile communication system. However, the statistical multiplexing proposed by the present invention can equally be applied to wired communication systems.

As explained previously, the present invention, when the activity of synchronized channels that maintain orthogonalilty is low or the transmitting data rate for the channels varies below a basic transmission rate, can achieve statistical multiplexing gain on channels from the primary communication station to the secondary communication station, an increase in activity of the limited orthogonal resources, a decrease in signaling traffic due to unnecessary channel allocation and de-allocation (or release), a simple transmission scheduling, a decrease in buffer capacity required by the primary communication station, a decrease in transmission time delay, and a seamless handoff in adjacent cells by using a statistical multiplexing method known as multi-dimensional orthogonal resource multiplexing that takes frequency, time and orthogonal code as an orthogonal axis.

Further, the present invention can distinguish almost an infinite number of channels when multi-dimensional

resource patterns are selected pseudo-randomly in comparison to the method which allocates the orthogonal resources fixedly. Also, in case of a collision that occurs due to a pseudo random selection of the hopping patterns, there is no need to stop the transmission of the colliding data symbols for the secondary communication stations which exist in an area where the transmission antenna beam is not overlapped like a sectorized or smart antenna.

The data symbols that are not transmitted due to collision of the hopping patterns between the channels in an identical transmission antenna beam, can be recovered through a channel decoding process of the secondary communication station without separately notifying the secondary communication station.

Also, using the present invention statistical multiplexing can be realized for all the orthogonal resources that include frequency, time, orthogonal code and polarization by implementing the method in the present invention.

WHAT IS CLAIMED IS:

1. A method for multi-dimensional orthogonal resource hopping multiplexing communication comprising a digital communication system that includes a primary communication station and secondary communication stations and a multi-dimensional orthogonal resource hopping multiplexing system for statistical multiplexing of the synchronous communication channels from said primary communication station to the secondary communication stations.

2. The method for multi-dimensional orthogonal resource hopping multiplexing communication as claimed in claim 1,

wherein said multi-dimensional orthogonal resource hopping multiplexing system comprises;

a multi-dimensional hopping pattern generator which is located in the transmitter of the primary communication station,

a data symbol modulator that selects the corresponding orthogonal resource patterns in terms of the output from said multi-dimensional hopping pattern generator

a collision detector and controller that detect whether a collision occurs or not among the multi-dimensional hopping patterns and compare the consistency of the data symbols toward the secondary communication stations between said

wherein said orthogonal resource#1 is frequency, the orthogonal resource#2 is transmission time or position of data symbol and orthogonal resource#3 is orthogonal code.

6. The method for multi-dimensional orthogonal resource hopping multiplexing communication as claimed in one of claims 1 to 4,

wherein said multi-dimensional orthogonal resource hopping is statistical multiplexing using a one-dimensional orthogonal resource hopping multiplexing method in which only one coordinate of the orthogonal axes hops.

7. The method for multi-dimensional orthogonal resource hopping multiplexing communication as claimed in claim 6,

wherein said one-dimensional orthogonal resource is frequency.

8. The method for multi-dimensional orthogonal resource hopping multiplexing communication as claimed in claim 6,

wherein said one-dimensional orthogonal resource is transmission time or position of data symbol.

9. The method for multi-dimensional orthogonal resource hopping multiplexing communication as claimed in claim 6,

consists of (transmission time or position, orthogonal code).

14. The method for multi-dimensional orthogonal resource hopping multiplexing communication as claimed in one of claims 1 to 4,

wherein said multi-dimensional orthogonal resource hopping is statistical multiplexing using a three-dimensional orthogonal resource hopping multiplexing method in which three coordinates of the orthogonal axes undergo hopping.

15. The method for multi-dimensional orthogonal resource hopping multiplexing communication as claimed in claim 14,

wherein said three-dimensional orthogonal resource consists of (frequency, transmission time or position, orthogonal code).

16. The method for multi-dimensional orthogonal resource hopping multiplexing communication as claimed in one of claims 1 to 4,

wherein said multi-dimensional orthogonal resource hopping of dimension N is statistical multiplexing using a multi-dimensional orthogonal resource hopping multiplexing method in which multi-dimensional (orthogonal resource#1, orthogonal resource#2, ..., orthogonal resource#N) coordinates of the orthogonal axes undergoes hopping.

resource hopping multiplexing communication as claimed in one of claims 1 to 3,

wherein said multi-dimensional orthogonal resource hopping pattern is allocated to each secondary communication station uniquely and therefore, become independent between the secondary communication stations.

22. The method for multi-dimensional orthogonal resource hopping multiplexing communication as claimed in one of claims 1 to 4,

wherein said multi-dimensional orthogonal resource hopping multiplexing is carried out for statistically sparse or bursty channels in order to attain statistical multiplexing gain.

23. The method for multi-dimensional orthogonal resource hopping multiplexing communication as claimed in claim 22,

wherein said bursty channels are communication channels toward the secondary communication stations whose transmission rate varies below the allocated basic transmission rate at the time of a call establishment.

24. The method for multi-dimensional orthogonal resource hopping multiplexing communication as claimed in claim 22,

wherein said bursty channels are communication channels toward the secondary communication stations whose

one of claims 1 to 4,

wherein the collisions of multi-dimensional orthogonal resource hopping patterns occurring from independent multi-dimensional orthogonal resource hopping patterns of said channels toward the secondary communication stations can cause not to transmit the data symbols of all corresponding channels during the symbol duration by previously detecting collisions at the primary communication station.

40. The method for multi-dimensional orthogonal resource hopping multiplexing communication as claimed in one of claims 1 to 4,

wherein said data symbols are transmitted when a comparison at the time of a collision of said multi-dimensional orthogonal resource hopping patterns shows that all the transmitting data symbols of corresponding channels are identical.

41. The method for multi-dimensional orthogonal resource hopping multiplexing communication as claimed in one of claims 1 to 4,

wherein said data symbols are not transmitted when a comparison at the time of a collision of said multi-dimensional orthogonal resource hopping patterns shows that all the transmitting data symbols of corresponding channels are not identical.

42. The method for multi-dimensional orthogonal resource hopping multiplexing communication as claimed in claim 41,

wherein the transmission power is increased for the transmitting data symbols after the transmitting data symbols are not transmitted because the transmitting data symbols are not identical at the time of a collision of said multi-dimensional orthogonal resource hopping patterns.

43. The method for multi-dimensional orthogonal resource hopping multiplexing communication as claimed in claim 42,

wherein said transmission power increase is allowed in such an amount and at an interval given by the system parameters.

44. The method for multi-dimensional orthogonal resource hopping multiplexing communication as claimed in claim 43,

wherein said two system parameters depend on the location of the data symbols which are not transmitted.

45. The method for multi-dimensional orthogonal resource hopping multiplexing communication as claimed in claim 44,

wherein said two system parameter values are equal to or greater than zero.

ABSTRACT

The present invention is related to a statistical multiplexing method and apparatus using a multi-dimensional orthogonal resource hopping multiplexing method in a wired/wireless communication systems where a plurality of communication channels, which are synchronized through a single medium, coexist.

The present invention, in order to implement a generalized statistical multiplexing communication system using a multi-dimensional orthogonal resource hopping multiplexing method, comprises a multi-dimensional hopping pattern generator which is located in the primary communication station, a data symbol modulator that modulates data symbols based on the corresponding orthogonal resource hopping pattern generated by said multi-dimensional hopping pattern generator, a collision detector and controller that detect whether a collision occurs or not among the multi-dimensional hopping patterns and compare the consistency of the data symbols toward the secondary communication stations in said collision interval, a transmission power controller that controls the transmission power of the remaining parts excluding the parts where the multi-dimensional hopping patterns collide and the transmission is stopped due to transmitting data symbol inconsistency and compensates for the loss in the average reception energy due to a transmission stoppage.